

What is claimed is:

1        1. A method of transmitting data over a communications network, comprising the steps of:

3            multicasting content in a first transmission over a data network from a sender to a multicast group comprising a plurality of receivers;

6            in each of said receivers concurrently performing the steps of:

8                detecting a missing portion of said content;  
9                and

10              responsive to said step of detecting, delaying for a random interval;

12              thereafter transmitting no more than one negative acknowledgement in a second transmission from one of said receivers to said sender; and

15              responsive to said negative acknowledgement multicasting said missing portion in a third transmission from 17 one of said sender and another of said receivers to said 18 multicast group.

1        2. The method according to claim 1, wherein said random interval has a lower limit given by

$$LL = (a_1 t_{min}) \times b$$

4            wherein  $\times$  is a multiplication operator,  $a_1$  is a proportionality constant,  $t_{min}$  is a minimal round trip transmission time between said sender and a respective one of

7 said receivers, and b is a size of a largest packet of  
8 said missing portion.

1 3. The method according to claim 1, wherein said ran-  
2 dom interval has an upper limit given by

$$UL = (a_1 t_{\min}) \times b$$

4 wherein x is a multiplication operator, a<sub>2</sub> is a propor-  
5 tionality constant, t<sub>max</sub> is a maximum round trip transmis-  
6 sion time between said sender and a respective one of  
7 said receivers, and b is a size of a largest packet of  
8 said missing portion.

1 4. The method according to claim 1, further compris-  
2 ing the step of

3 determining a current quantity of traffic on said  
4 data network;

5 wherein said second transmission is sent when said  
6 current quantity is less than a predetermined value.

1 5. The method according to claim 1, wherein said ran-  
2 dom interval is a shortest said random interval of said  
3 receivers.

1 6. The method according to claim 1, wherein said  
2 third transmission is sent by said sender.

1       7. The method according to claim 1, wherein said  
2       third transmission is sent by one of said receivers.

1       8. A computer software product, comprising a com-  
2       puter-readable medium in which computer program instruc-  
3       tions are stored, which instructions, when read by at  
4       least one computer, cause said at least one computer to  
5       execute a method of transmitting data over a data net-  
6       work, comprising the steps of:

7            multicasting content in a first transmission over  
8        said data network from a sender to a multicast group com-  
9        prising a plurality of receivers;

10          in each of said receivers concurrently performing  
11        the steps of:

12            detecting a missing portion of said content;

13            determining a random interval; and

14            responsive to said step of detecting, delaying  
15        for said random interval ;

16          thereafter transmitting no more than one negative  
17        acknowledgement in a second transmission from one of said  
18        receivers to said sender; and

19          responsive to said negative acknowledgement multi-  
20        casting said missing portion in a third transmission from  
21        one of said sender and another of said receivers to said  
22        multicast group.

1       9. The computer software product according to  
2 claim 8, wherein said random interval has a lower limit  
3 given by

$$LL = (a_1 t_{min}) \times b$$

5       wherein  $\times$  is a multiplication operator,  $a_1$  is a propor-  
6 tionality constant,  $t_{min}$  is a minimal round trip transmis-  
7 sion time between said sender and a respective one of  
8 said receivers, and  $b$  is a size of a largest packet of  
9 said missing portion.

1       10. The computer software product according to  
2 claim 8, wherein said random interval has an upper limit  
3 given by

$$UL = (a_1 t_{min}) \times b$$

5       wherein  $\times$  is a multiplication operator,  $a_2$  is a propor-  
6 tionality constant,  $t_{max}$  is a maximum round trip transmis-  
7 sion time between said sender and a respective one of  
8 said receivers, and  $b$  is a size of a largest packet of  
9 said missing portion.

1       11. The computer software product according to  
2 claim 8, further comprising the step of  
3       determining a current quantity of traffic on said  
4 data network;  
5       wherein said second transmission is sent when said  
6 current quantity is less than a predetermined value.

1       12. The computer software product according to  
2 claim 8, wherein said random interval is a shortest said  
3 random interval of said receivers.

1       13. The computer software product according to  
2 claim 8, wherein said third transmission is sent by said  
3 sender.

1       14. The computer software product according to  
2 claim 8, wherein said third transmission is sent by one  
3 of said receivers.

1       15. A computer system, comprising:  
2           a first computer;  
3           a second computer interconnected in a data network  
4 with said first computer, said first computer and said  
5 second computer receiving multicast content in a first  
6 transmission via said data network from a content server;  
7           wherein said first computer and said second computer  
8 have program instructions stored therein, which instruc-  
9 tions cause said first computer and said second computer  
10 to concurrently execute a method of transmitting data  
11 over a communications network, comprising the steps of:  
12           detecting a missing portion of said content;  
13           determining random intervals, wherein a first random  
14 interval of said first computer is shorter than a second  
15 random interval of said second computer; and

16       responsive to said step of detecting, said first  
17    computer delaying for said first random interval, and  
18    said second computer delaying for said second random in-  
19    terval; and

20       thereafter said first computer transmitting a first  
21    negative acknowledgement in a second transmission to said  
22    content server;

23       said content server resending said first negative  
24    acknowledgement to said second computer, wherein in an  
25    event that said second computer has not received said  
26    missing portion, said second computer suppresses a second  
27    negative acknowledgement therefor; and

28       receiving said missing portion in a third transmis-  
29    sion from said content server.

1       16. The computer system according to claim 15,  
2    wherein said random intervals each have a lower limit  
3    given by

$$LL = (a_1 t_{min}) \times b$$

4       wherein  $\times$  is a multiplication operator,  $a_1$  is a propor-  
5    tionality constant,  $t_{min}$  is a minimal round trip transmis-  
6    sion time between said content server and a respective  
7    one of said first computer and said second computer, and  
8     $b$  is a size of a largest packet of said missing portion.

1       17. The computer system according to claim 15,  
2 wherein said random intervals each have an upper limit  
3 given by

$$4 \quad UL = (a_1 t_{\min}) \times b$$

5       wherein  $\times$  is a multiplication operator,  $a_2$  is a propor-  
6 tionality constant,  $t_{\max}$  is a maximum round trip transmis-  
7 sion time between said content server and a respective  
8 one of said first computer and said second computer, and  
9  $b$  is a size of a largest packet of said missing portion.

1       18. The computer system according to claim 15,  
2 wherein said first computer further performs the step of  
3 determining a current quantity of traffic on said  
4 data network;

5       wherein said second transmission is sent when, said  
6 current quantity is less than a predetermined value.

1       19. The computer system according to claim 15,  
2 wherein said third transmission is sent by said content  
3 server.

1       20. The computer system according to claim 15,  
2 wherein said third transmission is sent by said second  
3 computer.